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THE CLIMATE OF THE LOWER RIO GRANDE VALLEY OF TEXAS[1]

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Comparatively little detailed work has been done on the climate of extreme southern Texas and the region of the Lower Rio Grande Valley. Page (1) has given a complete discussion of the rainfall of southern Texas, but no similar work has been done for the section on the other climatic elements. Kincer (2) has made general studies which include this area, and in a more detailed way has described the climate of the Great Plains (3) which includes the Lower Rio Grande Valley. Descriptions of the climate of the valley have been written by Potts (4) and other descriptions are given by the authors of the soil surveys of Cameron, Hidalgo, and Willacy Counties. However, since most of the studies have been generalizations from the study of larger units or else very brief descriptions of the climate of the valley itself, it seems desirable to make more detailed maps and graphs for the valley proper and from these data to describe the climate of the area.

The Lower Rio Grande Valley lies in the Gulf climatic province, as described by Ward (5) and in the extreme southwestern part of the southern Texas region considered by Page. In general it is an area of very mild, almost frost-free winters, with a moderate rainfall, which decreases rapidly from the coast toward the interior. The large amount of sunshine and the high rate of evaporation due to the location of this area only a few degrees north of the Tropics, causes the rainfall to be deficient and necessitates the use of irrigation waters for agriculture.

The data used in making the maps and charts for this study were secured from: (1) "Climatological Data" (**6**); (2) "Bulletin W" (**7**), and (3) published and unpublished records of the United States Weather Bureau station at Brownsville, Tex. (**8**). With the exception of Brownsville, all of these are cooperative stations and their records are broken from time to time. Rainfall is reported more completely than any other item. By using the long time record for Brownsville as a base, and adjusting the variable records for the other seven stations on it, it has been possible to construct a rainfall map for a 60-year period for the entire valley region. The formula used in adjusting these rainfall data is the one commonly used.[2] The monthly rainfall records were not adjusted, but the actual averages for each station were used in making the charts. Temperature was reported less completely than rainfall, but averages were determined for each station and charted. Sunshine records were kept over an eight-year period for four of the stations, but, other than that, all additional climatological data were reported for Brownsville only. There is also included a three-year average of evaporation data from a temporary station at Mercedes. The following table gives the general information in regard to the eight stations used in this study. The locations of these stations are shown on the rainfall map.

Station	County	Elevation, in feet	Length of record
			Years
Brownsville	Cameron	57	60
Point Isabel	do	15	4
San Benito	do	37	9
Harlingen	do	37	15
Raymondville	Willacy	31	18
Mercedes	Hidalgo	66	16
Mission	do	140	14
Riogrande	Starr	168	18

RAINFALL

The rainfall of the lower Rio Grande Valley region shows a marked decrease from the coast toward the interior. The map of average annual distribution (fig. 1) shows a range from more than 30 inches on the coast at Point Isabel to about 16 inches at Riogrande, in a distance of only a little more than 100 miles. This range is still more striking when the level topography is considered. Riogrande is in fact only 153 feet higher than Point Isabel, but if it were at the same level, the difference in precipitation would likely be greater. Page (**9**) found a decrease of 28 inches between Beaumont and Brownsville in a distance of 400 miles, but this range is even greater with approximately 15 inches decrease for 100 miles. In discussing the causes of this marked decrease in rainfall, Page (**10**) gives the following causes:

(1) The southwestern part is more out of the southerly moisture laden winds.

(2) The southwestern portion is more in the horse-latitude high-pressure belt for a larger part of the year, and therefor less often influenced by extratropical storms.

(3) Fewer tropical disturbances affect the southwestern part, on account of its western position in the Gulf of Mexico, which places it out of the line of usual travel of these storms from their southeastern source.

While this great range in rainfall has an effect on the natural vegetation to some extent, its significance to agriculture is not as great as might be expected, since the evaporation rate is high enough to make even 30 inches of rainfall insufficient for successful agriculture, and irrigation is practiced throughout the region where topography and soils are favorable. The average annual rainfall, while varying in distribution throughout the region, is possibly not as significant as the variation in the annual total rainfall. This is illustrated by the chart (fig. 2) of the Brownsville station with its variability over

[1] This article is an excerpt from a doctor-of-philosophy dissertation submitted at Clark University, Worcester, Mass., in April, 1931.

[2] Formula:

$$\frac{\text{Total rainfall for short record station}}{\text{Total rainfall for long record station (same years as short record station)}} = \frac{x}{\text{Total rainfall for long record station (60 years)}}$$

x = adjusted total for short record station for 60 years.

$\frac{x}{60}$ = adjusted annual rainfall for the short stations.

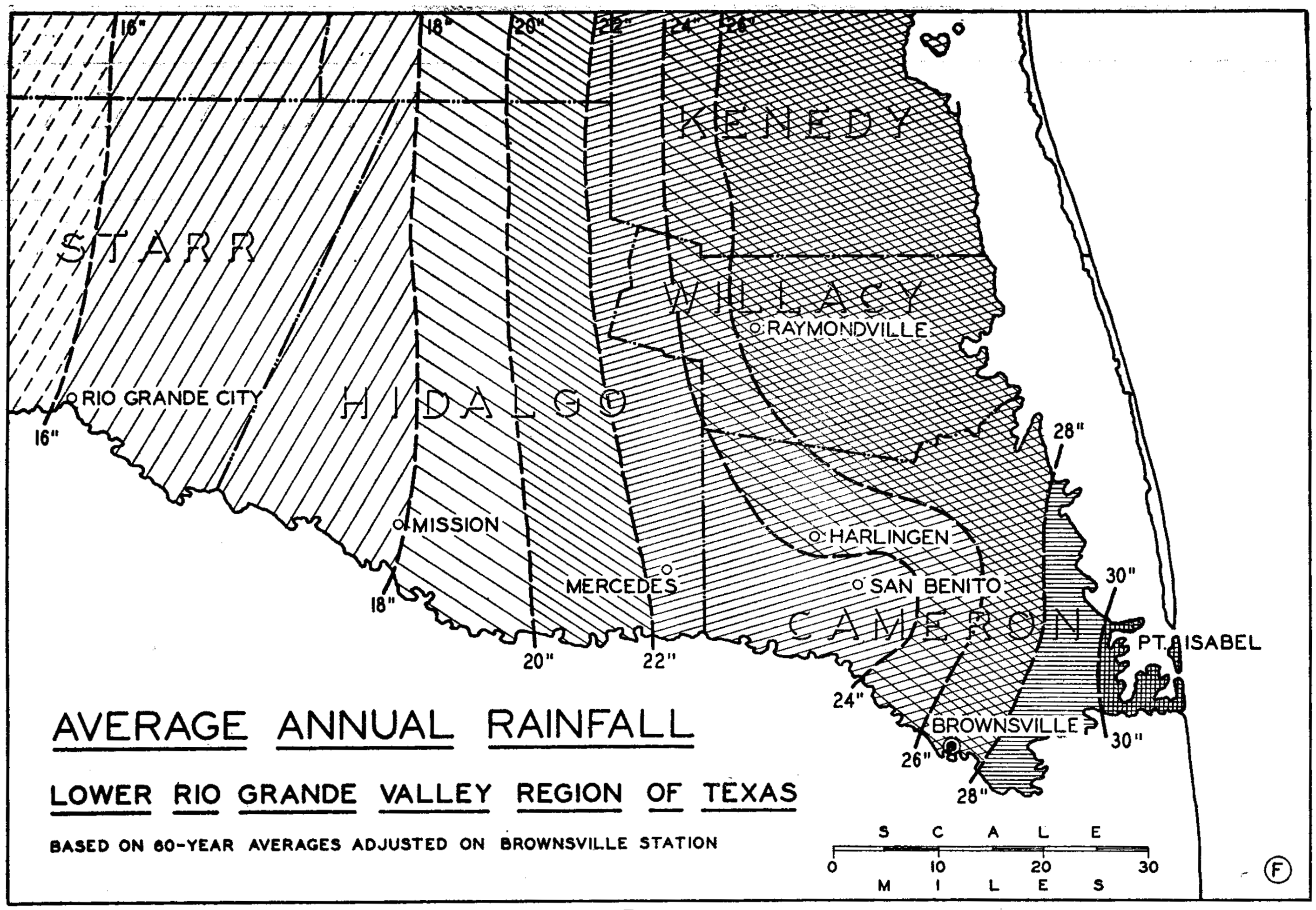


FIGURE 1

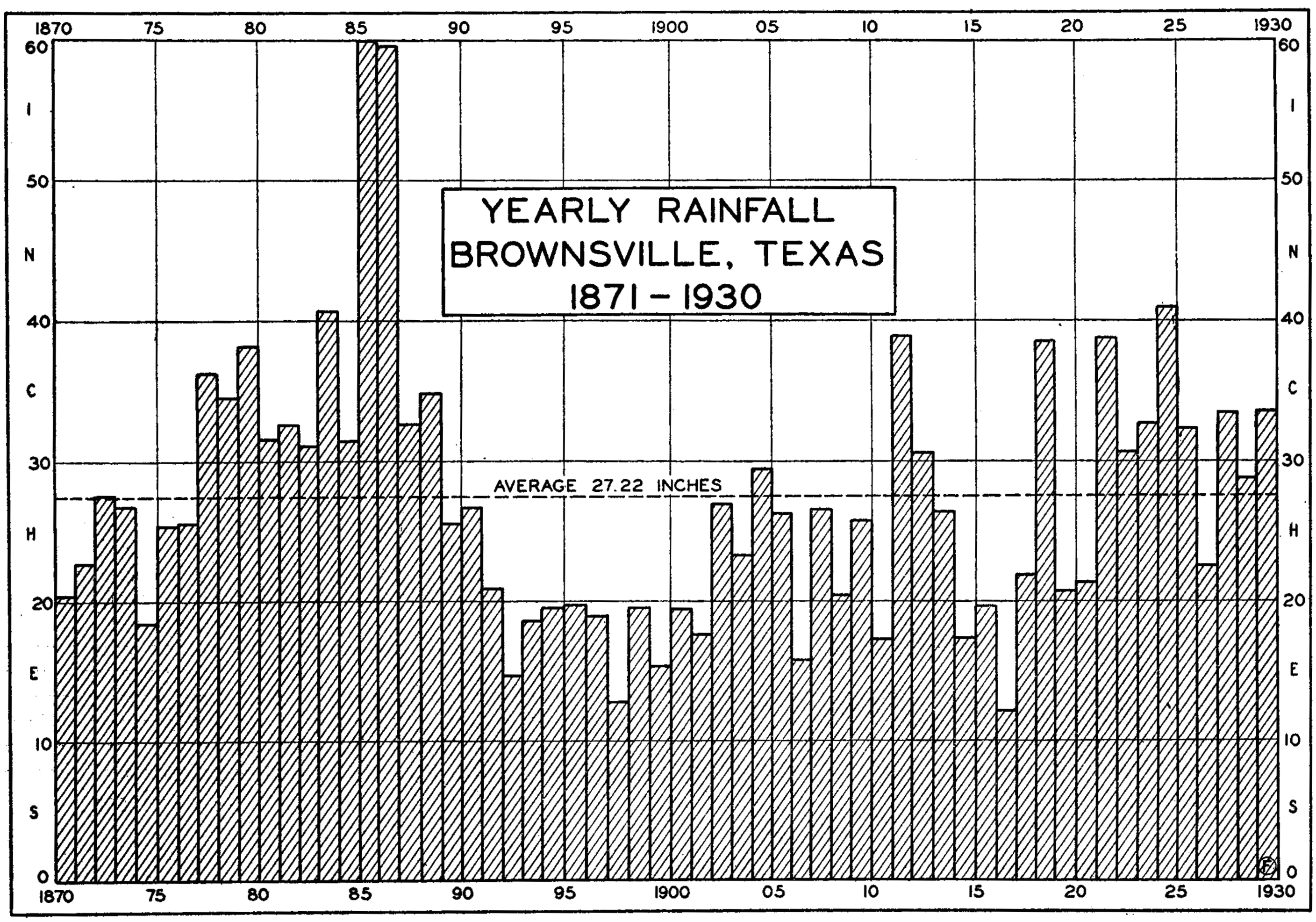


FIGURE 2

a 60-year period. With an average rainfall of 27.22 inches, Brownsville frequently suffers from periods of drought, which sometimes extend over a long period of years. The longest period of drought was during the years 1893 to 1902. During this 10-year period the rainfall did not total as much as 20 inches in any one year. Since this was before the development of irrigation in the valley, the crops that had been fairly successful during the wet decade preceding 1893 were failures. This protracted drought led to the development of irrigation, as it convinced the farmers that continued agriculture without it was impossible.

Records for the period show that the cattle industry that dominated the valley region before 1904 also suffered severely from this drought and many thousands of head died. A second drought period was from 1915 to 1917, but as irrigation was well developed by that date, there was not the inconvenience and loss from crop failures as was experienced during the earlier dry period. Kincer (**11**) notes both of these dry periods in his charts for the three sections of the Great Plains. The period from 1878 to 1887 was characterized by unusually heavy rainfall. Every year during that period had more than 30 inches of rainfall, and two years, 1886 and 1887, reached the high values of 60.06 inches and 59.82 inches, respectively. Since 1922 the rainfall for every year, except 1927, has been above the average. The absolute range in annual rainfall varies from 60.06 inches in 1886 to 12.15 inches in 1917. While detailed data for the other stations are not available for this long period, their variations are similar, and for that reason Brownsville may be taken as the type station. This tendency for periodic variations of rainfall is characteristic of the entire plains region and has had a great influence on agricultural development.

The chart of average monthly distribution of rainfall for the eight stations of the Lower Rio Grande Valley (fig. 3) shows a marked similarity in the course through the year. While there are local variations, the dominant feature of the rainfall of this region is that all stations are in the same rainfall region, which shows two pronounced periods of maximum precipitation. The first maximum comes in late spring, April to June. The second maximum usually comes in September, but sometimes in October. This September maximum is quite typical of the Texas coast, and has been called the "Texas coast type" by Ward (**12**). Tannehill (**13**) explains these two periods of maximum rainfall as follows:

> The prevailing southeasterly wind over Texas is in the nature of a monsoon, and its advance and retreat in May to June and September to October, respectively, are attended by increased intensity of rainfall, undoubtedly because of the attendant shift in wind direction.

The prevailing wind direction over Brownsville for a period of eight years shows a dominance of southeast winds for the spring months and again for the late summer months. From November through January the prevailing winds are northwest, and during that period the least rain falls over the valley. This is of great value to agriculture, as the mid-winter season is the period of maximum harvest for both fruit and truck and heavy rains during that time would seriously handicap the industry.

Of slight interest is the maximum variation in monthly precipitation. The absolute maximum of all of the stations is 19.21 inches at Brownsville in September, 1925, 10.44 inches falling during a 24-hour period. As to the minimum, practically every station has experienced rainless months.

HUMIDITY AND EVAPORATION

The average relative humidity at noon at Brownsville is shown in Figure 4. There is a very slight variation between summer and winter. The months of lowest relative humidity follow the months of maximum rainfall. Of more significance than the relative humidity of the region is the amount of evaporation. The only evaporation data that have been collected in the valley were worked out by the United States Department of Agriculture during a 3-year period from August, 1917, to July, 1920, inclusive, at Mercedes, Tex. The results of this experiment are given below (**14**).

Average evaporation for 3-year period (in feet)

Month	From a 5-foot tank	From a 2-foot tank	From a 1-foot tank
January	0.395	0.481	0.505
February	.264	.367	.664
March	.574	.570	.817
April	.658	.898	.996
May	.786	.942	1.016
June	.687	.812	.906
July	.745	.894	1.057
August	.813	.889	1.226
September	.651	.784	1.084
October	.488	.684	.706
November	.340	.616	.494
December	.376	.348	.655
Total	6.777	8.285	10.126

This table shows a great range in the evaporation rate between winter and summer for all three sizes of tanks. The August evaporation is more than twice that of the January rate. The total for the three tanks also show an evaporation rate of 6 to 10 feet, or about 75 to 125 inches. Since most of the irrigation ditches that have been constructed in the valley in the past are of the open type, this high rate of evaporation causes a heavy loss of the water that is diverted from the river into the ditches. This has led in recent years to the development of smaller main canals and covered laterals.

CLOUDINESS

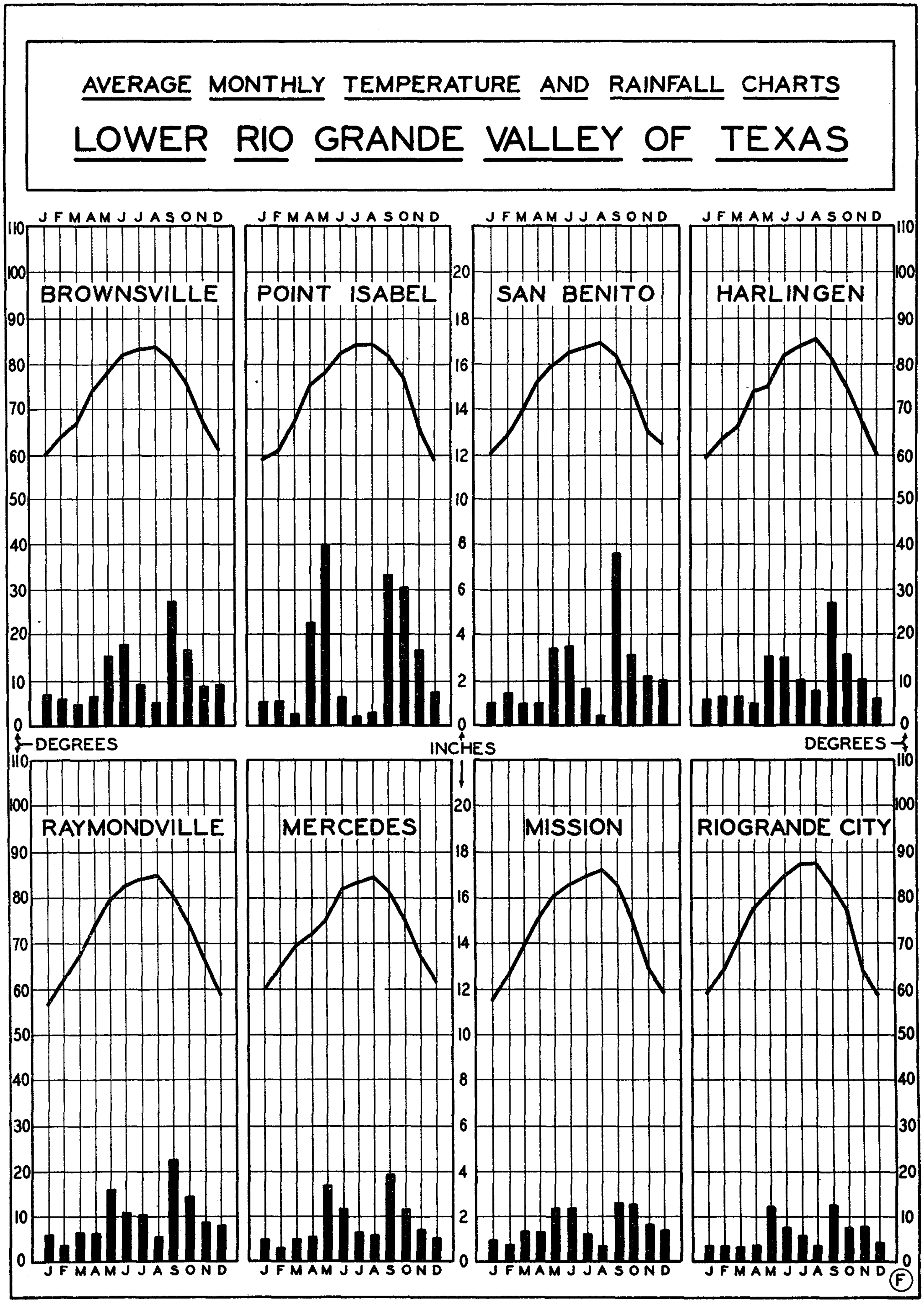
Due to the fact that sunshine data are not kept by some of the stations of the area,[3] only four stations could be used on a comparative basis and these are for an average of only eight years. The number of days reported as clear, partly cloudy, and cloudy are given below:

Station	Clear	Partly cloudy	Cloudy
Brownsville	134	138	93
Harlingen	236	70	59
Mercedes	187	69	109
Raymondville	162	132	71

SUNSHINE

From the files of the United States Weather Bureau at Brownsville, additional data were obtained as to the per cent of possible sunshine at that station. Figure 5 shows this information in graphic form. While detailed statistical information is lacking for a study of this topic, the total amount of sunshine is quite large, especially during the winter season, and this, coupled with the mild

[3] There is but one sunshine station in this area, namely, Brownsville. Cooperative stations report only clear, partly cloudy, and cloudy days.—*O. L. Fassig.*



AVERAGE MONTHLY TEMPERATURE AND RAINFALL CHARTS
LOWER RIO GRANDE VALLEY OF TEXAS
J F M A M J J A S O N D
BROWNSVILLE
POINT ISABEL
SAN BENITO
HARLINGEN
RAYMONDVILLE
MERCEDES
MISSION
RIOGRANDE CITY
DEGREES
INCHES
DEGREES
0 10 20 30 40 50 60 70 80 90 100 110
0 2 4 6 8 10 12 14 16 18 20

FIGURE 3

winter temperature, is a great asset to the area in attracting winter tourists as well as in aiding the harvesting of crops.

WINDS

The winds of the Lower Rio Grande Valley are prevailingly from the southeast, particularly during the summer season. This not only brings heavy rainfall during that season, but also tends to reduce the temperatures. The average annual wind directions for Brownsville for morning, noon, and evening, over a period of eight years, is shown in the wind roses. (Fig. 6.)

The seasonal changes are shown by the monthly frequency wind roses for Brownsville. (Fig. 7.) From February to October, inclusive, the winds are dominantly from the southeast. November, December, and January

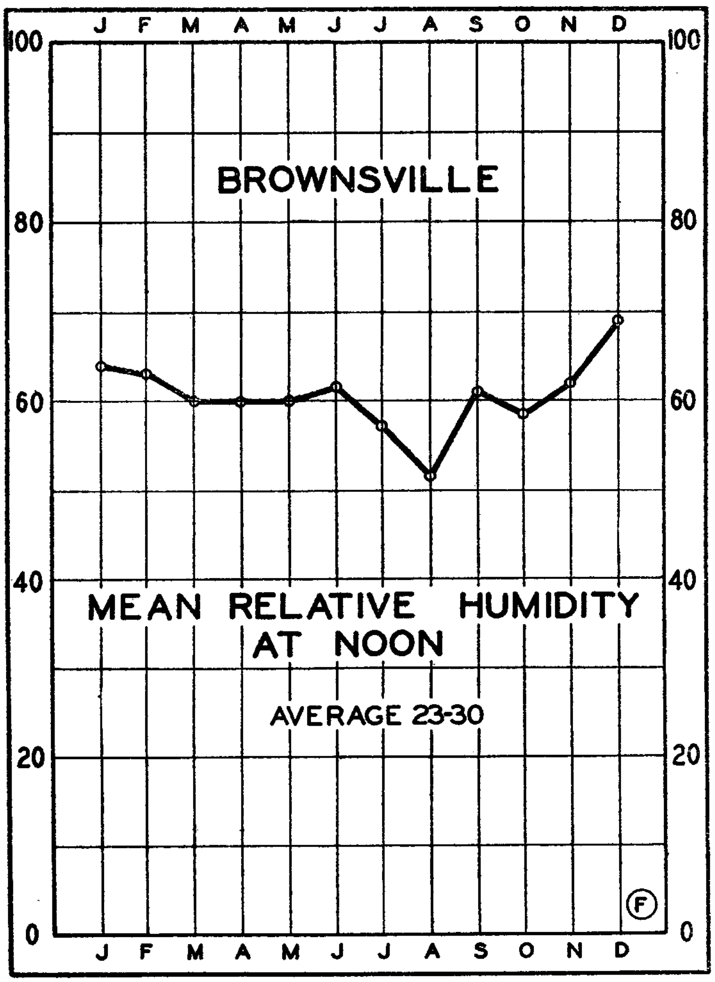


Figure 4

have a larger number of winds from the north and northwest than the other nine months. During these three winter months, though the winds are prevailingly from the north and northwest, the frequency of southerly winds is almost equal to that of the northerly winds. By February there is a marked diminution of the northerly winds, and an increase of southerly and southeasterly winds. In April the north and northwest winds become negligible and do not again assume importance until September. They increase during October, and become prevailing during November. The table below gives the prevailing wind direction for each month of each year from 1923 to 1930, inclusive. (15)

Month	1923	1924	1925	1926	1927	1928	1929	1930
January	S.	N.	N.	N.	S.	S.	N.	NW.
February	S.	S.	S.	S.	SE.	SE.	NW.	SE.
March	S.	S.	S.	S.	S.	S.	S.	SE.
April	S.	S.	SE.	SE.	S.	S.	SE.	SE.
May	S.	S.	SE.	SE.	S.	S.	SE.	SE.
June	SE.	S.	SE.	S.	S.	S.	SE.	E.
July	S.	S.	S.	S.	S.	SE.	SE.	SE.
August	S.	S.	S.	S.	S.	SE.	SE.	SE.
September	S.	SE.	S.	SE.	SE.	N.	SE.	SE.
October	N.	N.	S.	S.	S.	SE.	SE.	E.
November	N.	S.	N.	S.	S.	N.	NW.	S.
December	S.	N.	N.	S.	N.	N.	SE.	NW.

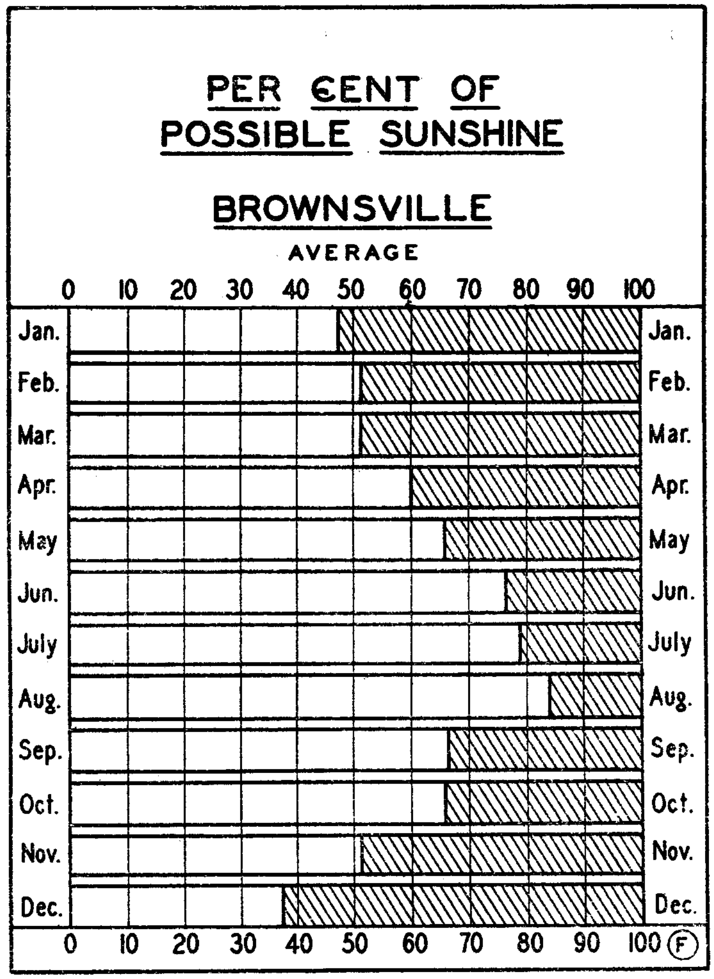


Figure 5

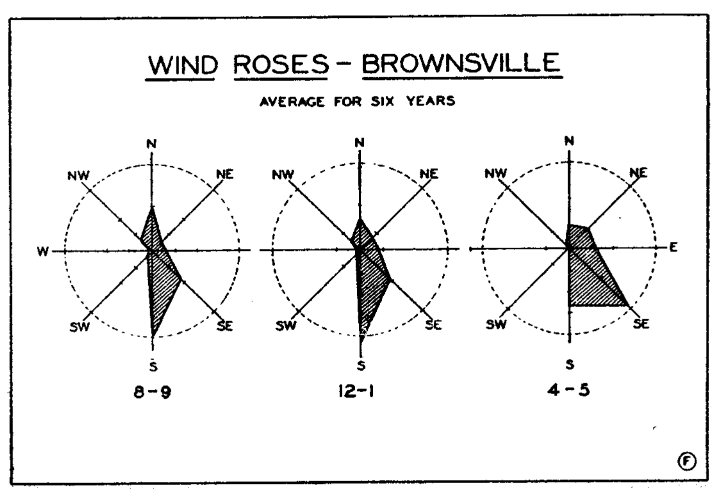
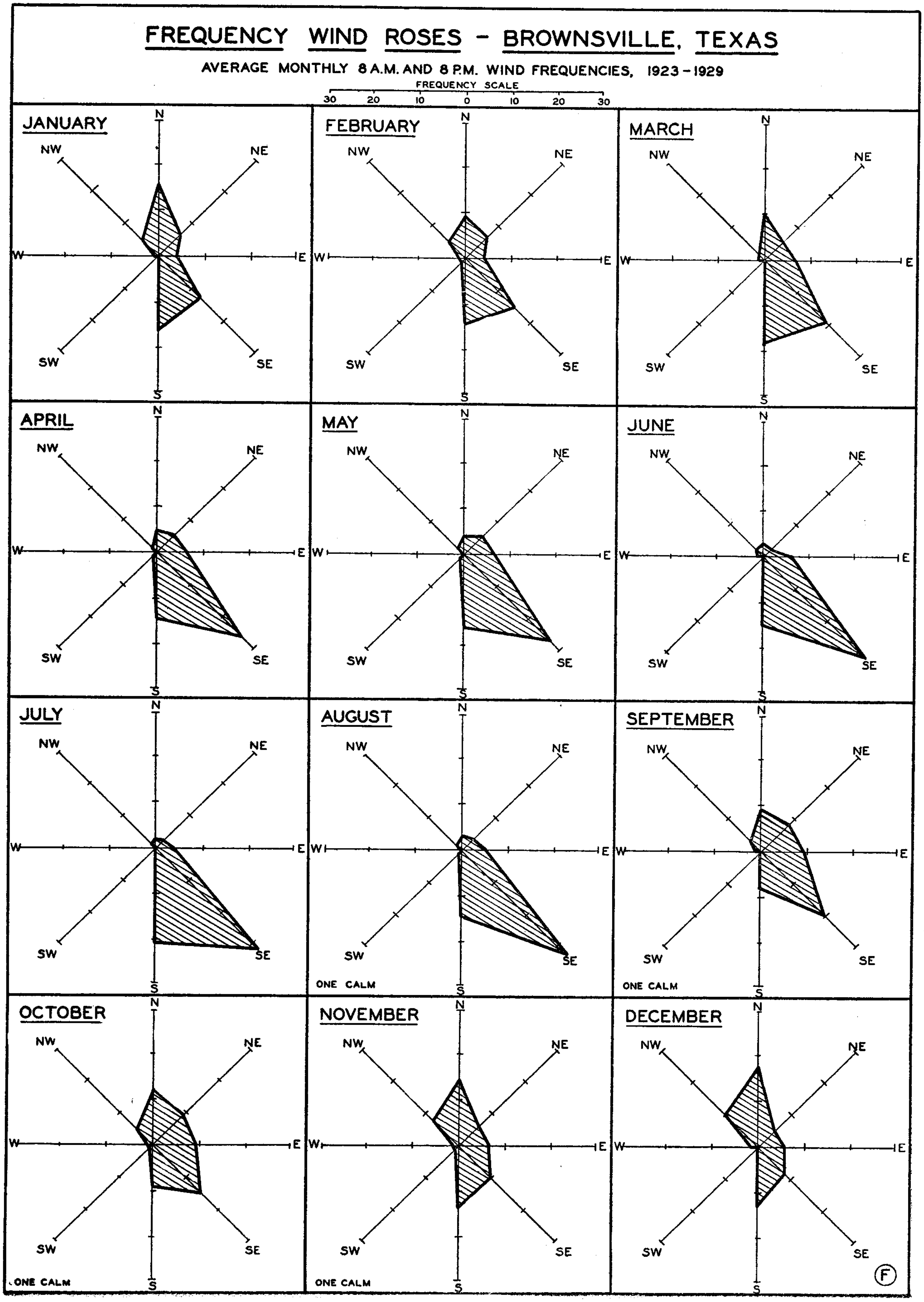


Figure 6


FREQUENCY WIND ROSES - BROWNSVILLE, TEXAS
AVERAGE MONTHLY 8 A.M. AND 8 P.M. WIND FREQUENCIES, 1923-1929
FREQUENCY SCALE
30 20 10 0 10 20 30
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
N
NE
E
SE
S
SW
W
NW
ONE CALM
F

There is a slight variation in the prevailing monthly wind direction from year to year, but this variation is not of significance.

The prevailing wind direction therefore exerts a continental influence in the valley from November through January and produces a marine effect during the remainder of the year. The highest recorded wind velocity at Brownsville was 44 miles per hour, October 20, 1926. This was a north wind. While the absolute maximum wind velocity is not high, the average wind velocity is by no means low, particularly during the period of the "norther." This relatively stiff wind, coupled with subfreezing temperatures, is a great handicap to the citrus industry in that it makes the smudging of orchards of little value, as the wind will carry the smoke and warm air out of the orchard as fast as the orchard heaters can produce them. The importance of this factor of wind is shown in the many types of wind-breaks that are being used in the area.

TEMPERATURE

Figure 3 gives the average monthly temperature for the eight stations of the valley. All have smooth curves with a range of about 25°. The range of temperature is lowest at Brownsville, 24°, and highest at Riogrande, about 30°. August is in each case the month of maximum temperature. Possibly this is due to the fact that the Gulf of Mexico is warmest in that month (**16**) and that the prevailing wind is from the south or southeast. January is in most cases the month of minimum temperature. This month is the last of the three in the season when the winds are prevailingly from the land, and possibly marks the extreme influence of the cold northern interior of the continent on this area. February usually warms up rapidly when the winds shift to the southeast, and again blow from the Gulf. The absolute maximum temperature recorded in the valley is 110° at Mission, July 12, 1923, while the absolute minimum is the record of 12° at Brownsville, on February 13, 1899. This gives an absolute range of temperature for the valley of 98°.

The summer temperatures, while high, are not unbearable, due to the presence of the sea breeze. The winters have mild temperatures, except for one or two cold periods of short duration each year. It is these cold snaps that cause the great hazard to fruit and truck growing in the valley. In a study made by the Texas Agricultural Experiment Station, comparisons were made between Brownsville, Tex., Eustis, Fla., and Redlands, Calif. All three stations are located in citrus-producing areas. The record is as follows: (**17**)

Eustis (31 years), 159 times below 32°; average, 5.12 times a year.

Redlands (16 years), 218 times below 32°; average, 13.62 times a year.

Brownsville (28 years), 101 times below 32°; average, 3.52 times a year.

From these figures it seems that the Lower Rio Grande Valley is more favored than either of the other two areas, but, on the other hand, neither of them have had as low a temperature as Brownsville. However, the actual temperature is not as significant as the duration of the cold spell below the freezing point. In a study of the probabilities of recovery from subnormal temperatures along the Texas coast, Tannehill (**17**) found that the probability of a rise increases as the temperature falls, and that there is a 44 per cent probability of a rise of more than 10° at temperatures between 20° and 28°.

Most of the cold waves or "northers" that reach this section with subfreezing temperatures are of the dry norther type and are frequently accompanied by high winds. If the wind dies down, severe freezes are likely to occur. In the valley area most of the "wet northers" do not have freezing temperatures. Tannehill (**18**) found that severe wet northers, with more than two days of freezing temperatures, occurred at Galveston about once in three or four years. The probability of their occurrence should be even less than that in the Lower Rio Grande Valley, which is south of Galveston by nearly 4° of latitude.

The length of the growing season is rather difficult to figure. Actually it is 12 months long, as there is no period when crops are not being produced. According to the Atlas of American Agriculture, part 2 section 1 (**19**), killing frosts are liable to occur annually over the upper part of the valley, but only about once in two years in the area around Brownsville. Frost is highly variable in the area.

HAIL AND SNOW

Hail is quite rare in the Lower Rio Grande Valley. Only a few times has hail been noted, and these storms had no very destructive effects. The most destructive hailstorm that has occurred in the valley in recent years was the one at McAllen, April 29, 1930. This storm, accompanied by hail and rain, caused a damage to crops and buildings estimated at $50,000. (**20**)

Snow is also rare in this area. Although practically every station has reported a trace of snow during some winter, and occasionally as much as 1 inch is reported, most of the winters are snowless.

SUMMARY

The climate of the Lower Rio Grande Valley of Texas is semitropical. The rainfall varies from more than 30 inches on the coast to about 15 inches at the upper end of the area. Most of the rain comes during the period from April to October, and the remaining part of the year is relatively dry. There is a great fluctuation in the annual rainfall, which is characteristic of the Great Plains type. A period of wet years is followed frequently by a period of very dry years. The drought hazard is so great that irrigation is necessary, particularly with the high rate of evaporation. The winds are dominantly from the Gulf of Mexico, and modify the summer temperature. The winters are quite mild, although occasional cold spells cause great damage to crops. Killing frosts may occur any year, but do not every year. Destructive storms are rare and snow seldom falls.

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AERONAUTICAL METEOROLOGY IN GERMANY

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The following account of the work of the German national meteorological flying stations is taken from nine papers by Kurt Wegener, A. Lohr, H. Steinhaeusser, H. O. Steiner, P. Lautner, and K. O. Lange that were read at one of the periodical meetings of the members of the service held at Hamburg on April 24–26, 1930, and subsequently printed in the Meteorologische Zeitschrift, volume 47, September 1930, page 325–345.

Daily airplane flights are made at Berlin, Hamburg, Darmstadt, Munich, and Koenigsberg. The ships and pilots belong to the national school for commercial pilots. The meteorological work is under the Imperial Ministry of Commerce.

The object of the flights is primarily the supplying of information for the benefit of air commerce, but experimental and research meteorology and the testing of aeronautical instruments are provided for by attaching a trained meteorologist to each ship. The resulting benefit to the meteorologists has been so great that it is proposed to make experience in the high meteorological ascents a prerequisite for all who have to do with issuing meteorological information to aircraft.

The flights are made simultaneously, to at least 5,000 meters (and a maximum of 7,360 meters has been attained. The peak altitude is timed to be reached at 8 a. m. Central European time when the observers on the ground are making the observation for the synoptic map. After the descent the results have to be reduced in time to be broadcast by radio at 10 a. m.

The daily flights were begun in April, 1927. During the year 1928 high flights were made on 86 per cent of all available flying days; in 1929 on 98 per cent. At Hamburg 45 per cent of the flights were "cloud flights" on which neither the ground nor the horizon was visible and it was necessary to rely on the gyroscopic level.

For the sake of quick reduction of the record sheets from the meteorographs, the ascent is made at an unchanging rate. Inversions are depended on to connect the different traces on the sheet. Sounding balloon observations have been used to check the results of the airplane records. The first extensive series of such comparisons during the international observations of December, 1929, showed not only satisfactory correspondence of both temperature and humidity, but showed that the airplane meteorograph gave more detail on account of its more open scale.

The structure and transformations of clouds and their relation to the movements of the air masses of the Bjerknes polar front theory have been an important concern of the observers, and many important relations have been derived from observation. For example, "if the lower boundary of a continuous cloud sheet consists of fracto-stratus or fracto-nimbus then an airplane can emerge from the cloud sheet in descent without great danger, because the existing turbulence of the ground air layer always provides for the breaking of the lowest cloud zone.

"If a warm air wave comes in on the front of a depression, it is almost always indicated a day before by a formless haze in the southwest sky, while toward the other quarters of the sky the old air masses appear clear."

Some new cloud forms discovered on the high flights have received the names of their discoverers, viz, "Wegener air waves," "Lohr cloud stripes."

Thunderstorms are found to be observable at much greater distances, some as far away as France, Switzerland, and the North Sea. Studies of the vertical currents in and around cumulus show upward velocities of 2 to 4 meters per second; in cumulo-nimbus, 10 to 15. In front of line-squalls strong vertical bumpiness extends 3 to 4 kilometers, but this vanishes directly over the squall roll, and the space behind the squall head is very smooth. Further details regarding flights in clouds are contained in MONTHLY WEATHER REVIEW, November, 1931, pages 430 and 431.

Icing of airplanes has been a particular object of research. On 150 flights at Koenigsberg icing occurred on 16. The worst case was on December 17, 1929. After 9 minutes the temperature having fallen to −9.8° C., the machine was suddenly covered with ice that reached a